LANL Effort on Au+Au Collisons

Pat McGaughey (P-25)

- $J/\Psi \rightarrow \mu^+\mu^-$
- Open charm (D mesons)
- Hadrons at $|y| > 0$
- Multiplicity and Vertex Detector (MVD)
- Future interests

Muons

MVD

PHENIX

Physics

NNSA

Los Alamos

Au+Au: Physics Goals

- Suppression/enhancement of J/Ψ yield in Au+Au relative to scaled p+p and d+Au
- Extract open charm yield in Au+Au collisions to help disentangle J/Ψ suppression due to a (possible) QGP from nuclear medium effects
- pion, kaon, heavy flavor production for non-zero rapidity
- dN/dη, multiplicity, reaction plane from MVD (Multiplicity and Vertex Detector)

All contribute to the goal of detecting and characterizing the quark-gluon plasma.

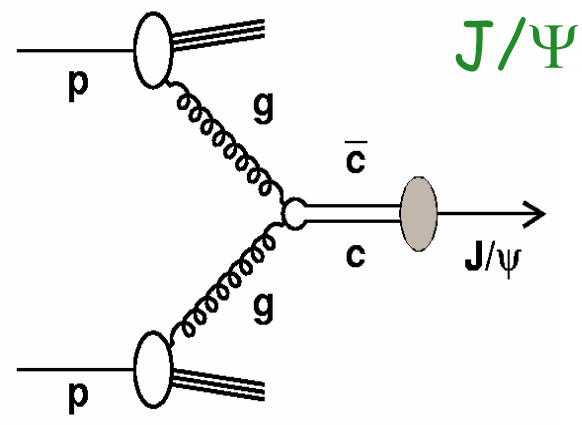
J/Ψ Suppression in Au+Au?

``J/Ψ suppression by quark-gluon plasma formation,'' Matsui and Satz 1986. Predicted J/Ψ suppression due to color screening.

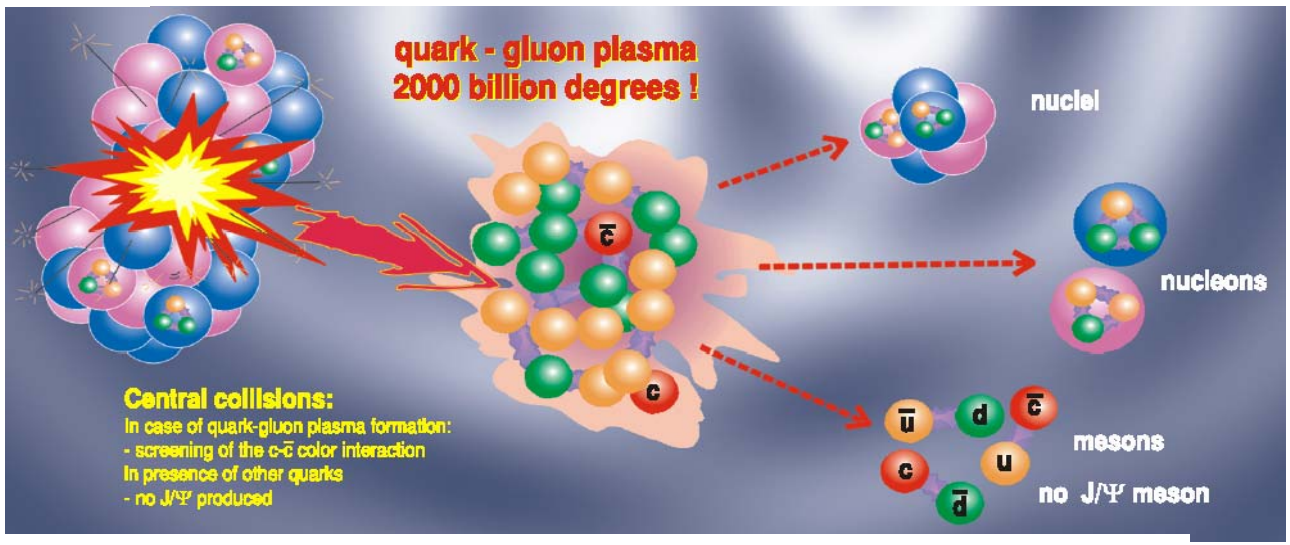
Expectation for Au+Au -> J/Ψ
pA effects scaled up PLUS:

- Hot hadron gas, comovers
- QGP/dense matter modifications to production:
  - Debye screening (suppression),
  - Enhancement in coalescence models, D+D↔J/Ψ+X
  - Thermal production of charm
  - Energy loss and dead cone effect

Charm and J/Ψ in Heavy Ion Collisions

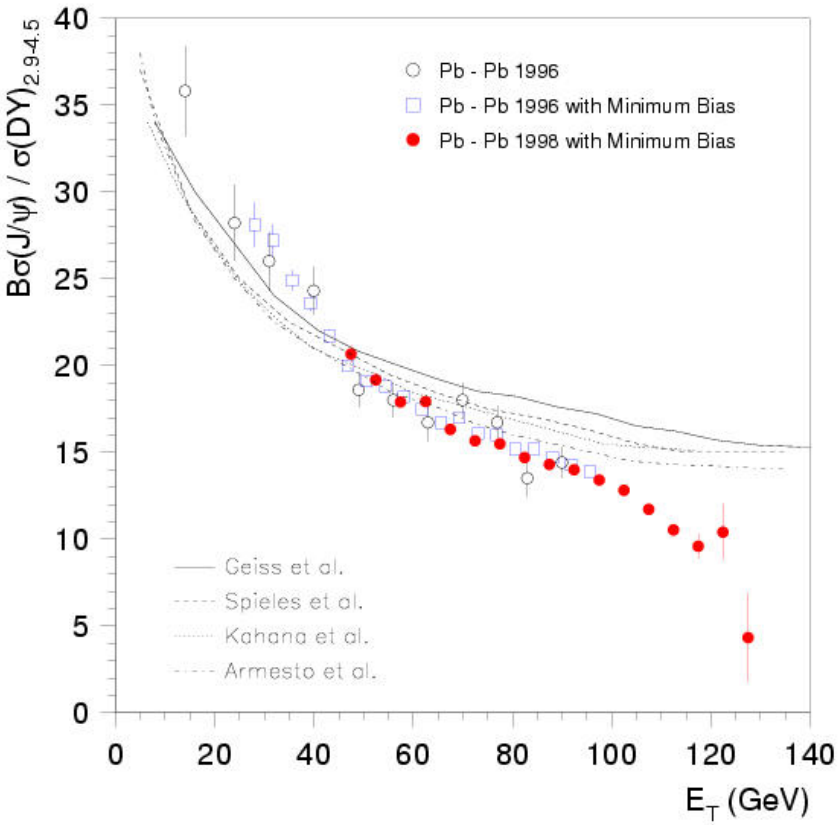


J/Ψ production by gluon fusion

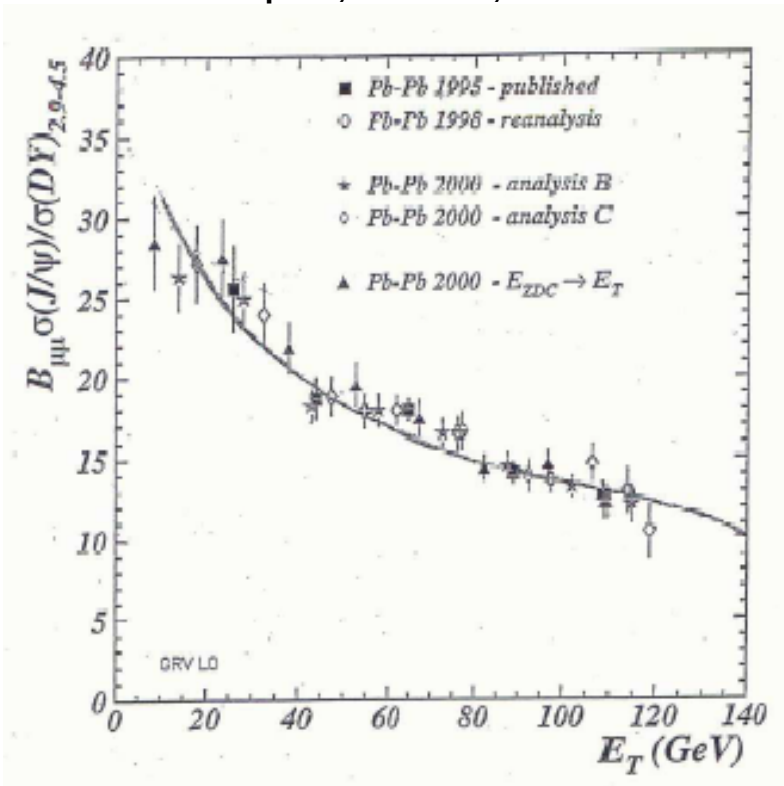


Must fully understand pp, dAu production to see suppression / enhancement beyond “normal nuclear suppression.” Need to measure over large kinematic region (varies Bjorken-x).

J/Ψ Suppression in Pb-Pb at NA50



A. Capella, D. Sousa, nucl-th/0303055

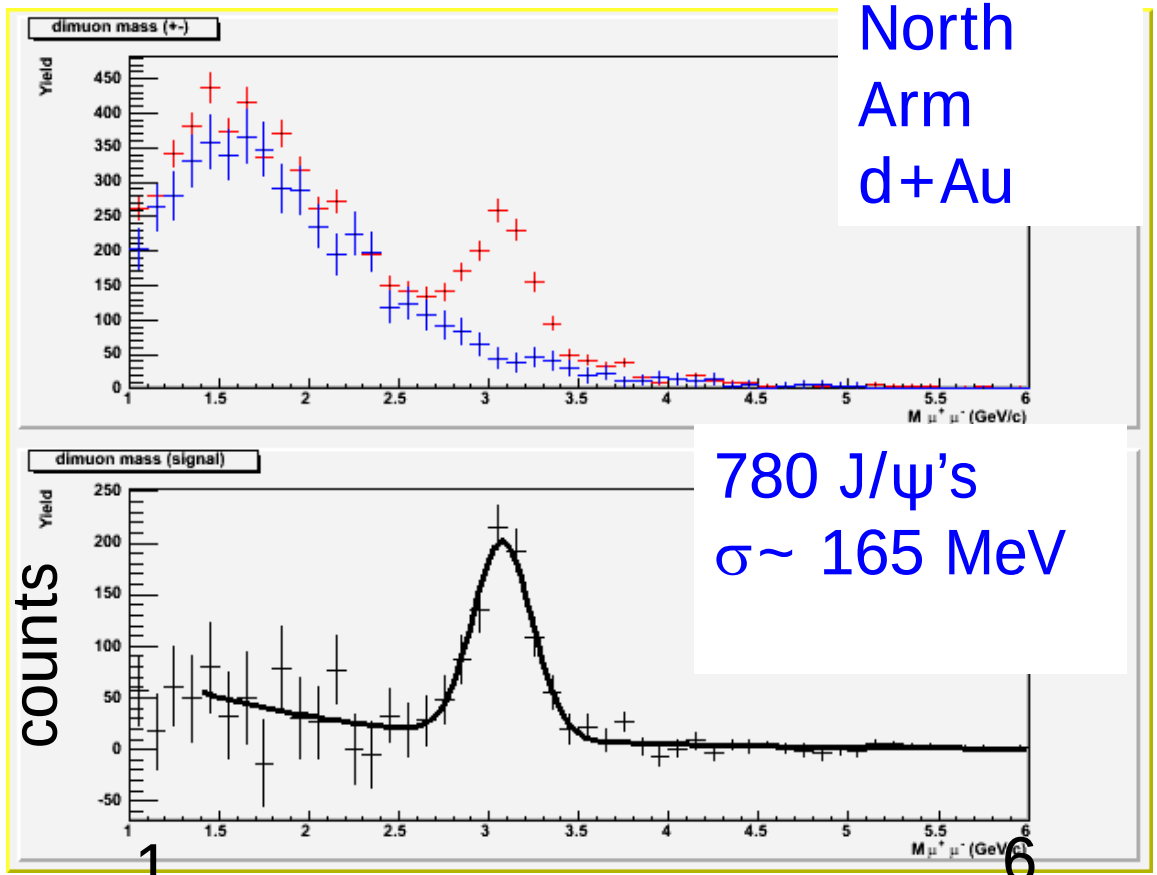


- Early results at large E_T showed suppression beyond expected nuclear effects
- Final data seem consistent with "normal nuclear suppression" ?
- Theorists have produced various non-QGP models which reproduce data:
  - Statistical coalescence model (also needs enhanced open charm)
  - Comovers
- RHIC data on J/Ψ highly desired to give another data point(s) to compare to PbPb results and implied expectations

J/Ψ Data Analysis

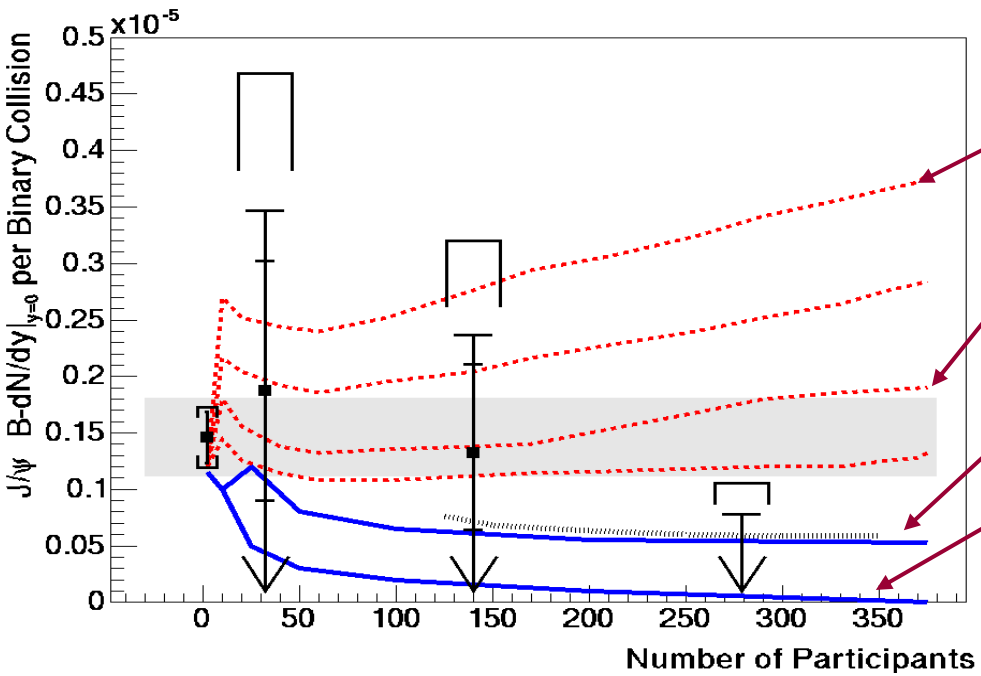
The LANL team has led the muon arm effort, including the extensive work to extract the J/Ψ signal from the p+p and d+Au data.

We will also be leaders in the effort to extract the J/Ψ signal from the muon arms in run-4. This work is underway.



J/Ψ in Au+Au Collisions

Here is what we have from Run-2 ($J/\Psi \rightarrow e^+e^-$):



R. L. Thews, M. Schroedter, J. Rafelski, Phys Rev C 63, 054905
Plasma Coalescence Model

Binary Scaling

Absorption (Nuclear + QGP) + final-state coalescence

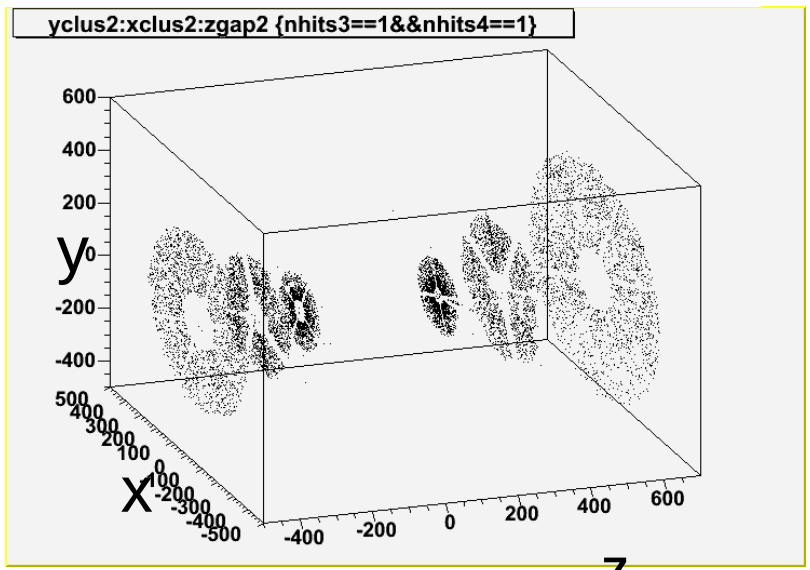
Absorption (Nuclear + QGP)
L. Grandchamp, R. Rapp, Nucl Phys A709, 415; Phys Lett B 523, 60

Only 13 counts, Need much more Luminosity!
Expect 1600 in each muon arm, 400 from central arm in run 4.

Run-4 Muon Arm Performance

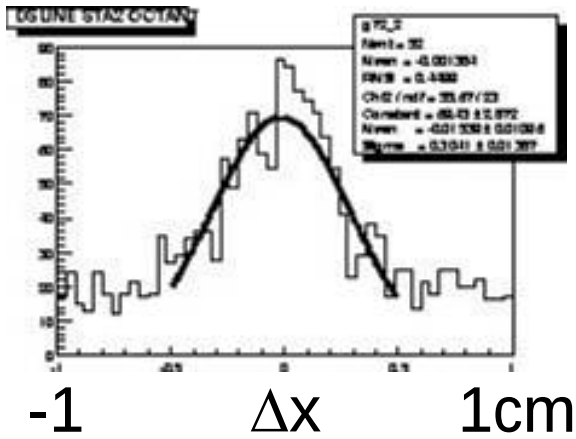
•We are presently filtering the Au-Au dimuon data to pull a J/Ψ signal out of minimum bias events.
•Alignment has been checked and is OK within limited statistics. (Need ~100 micron accuracy).
•Simulations of J/Ψ embedded in real Au-Au events give good mass resolution and fair reconstruction efficiency.

Radiograph of μTr hits:



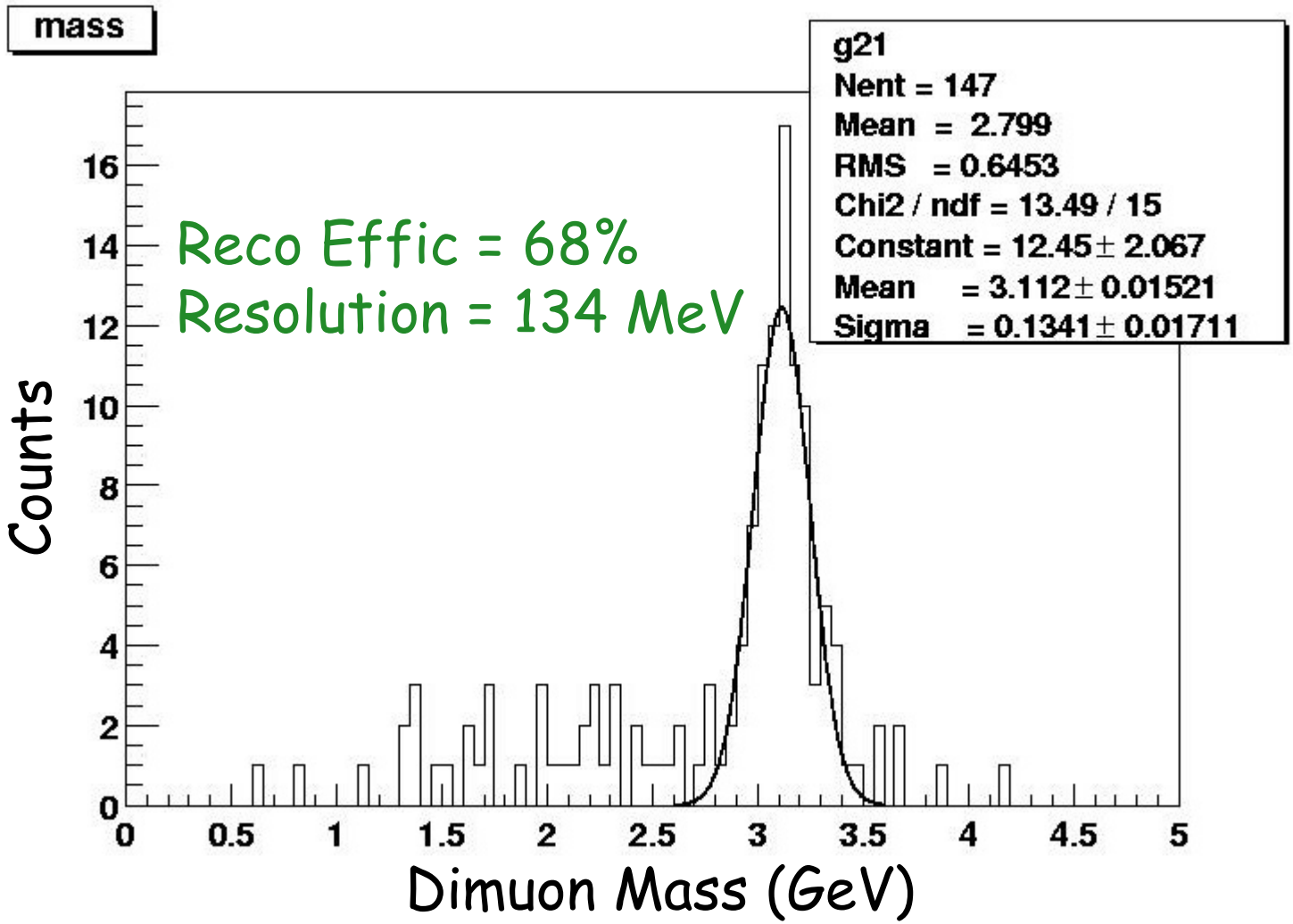
Lots of hits!

Sample plot from alignment work:



Simulated J/Ψ Embedded in Real Run 4 Au-Au Events

North Arm

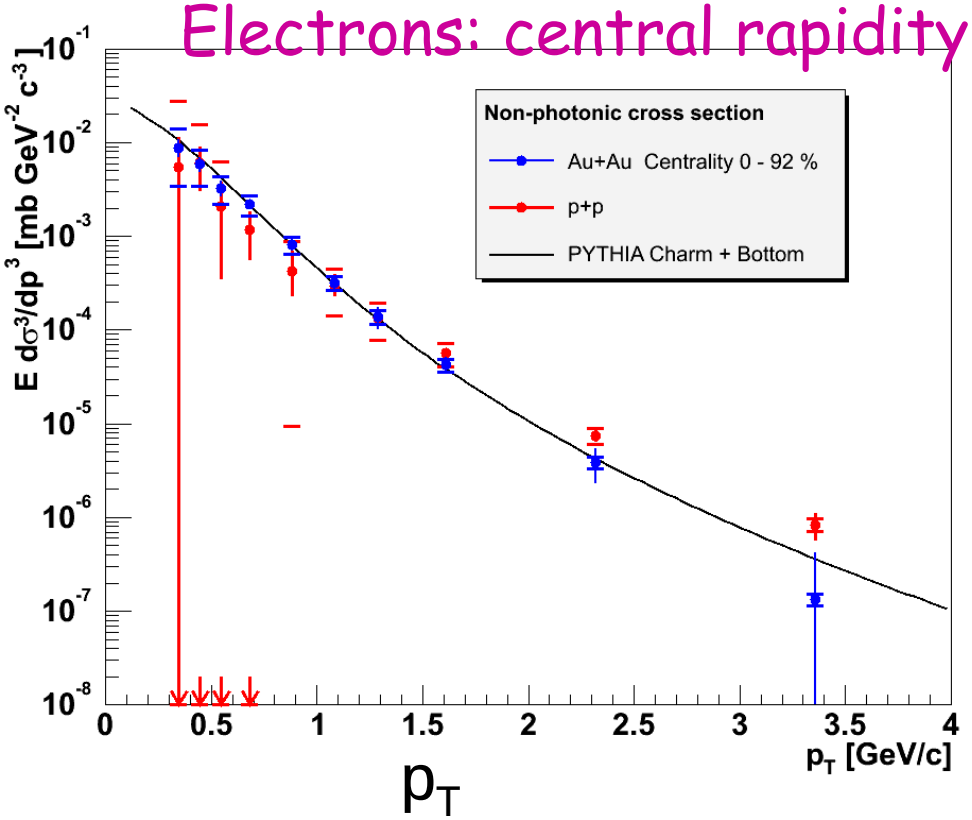


Open Charm Production from Single Leptons

Cocktail = π^0 Dalitz + γ conversions, etc

Excess over cocktail = c+b:

Electrons: central rapidity

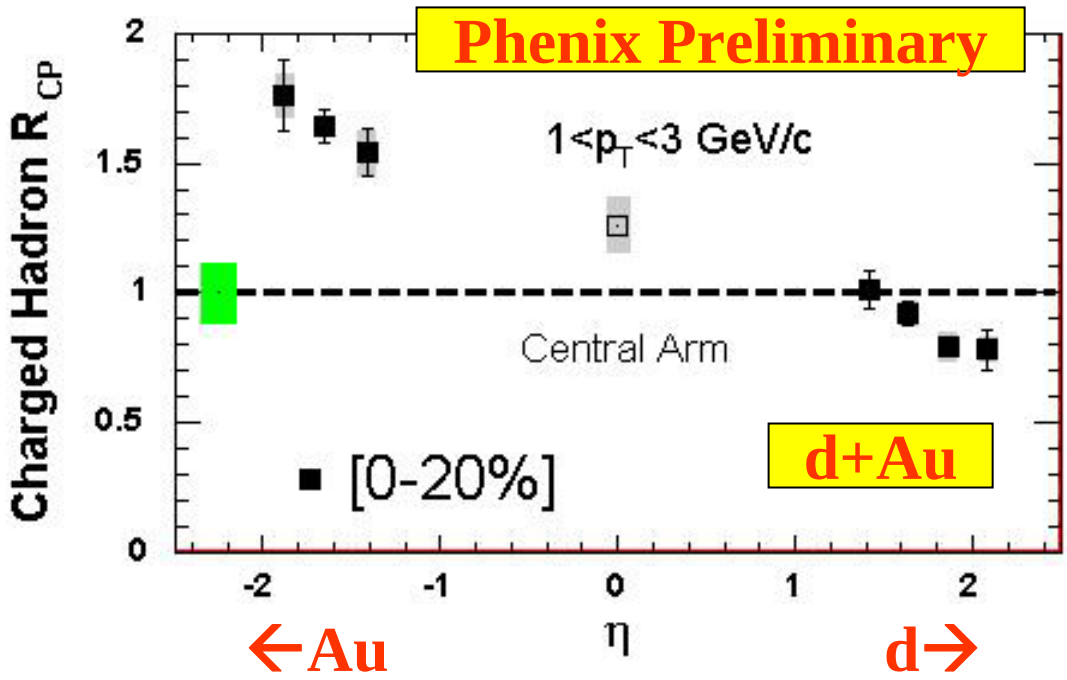


No statistically significant difference between scaled pp and AuAu open charm yields at mid-rapidity.

Forward y (muons): should show some suppression (if shadowing comes into play) – the relevant comparison to forward J/Ψ

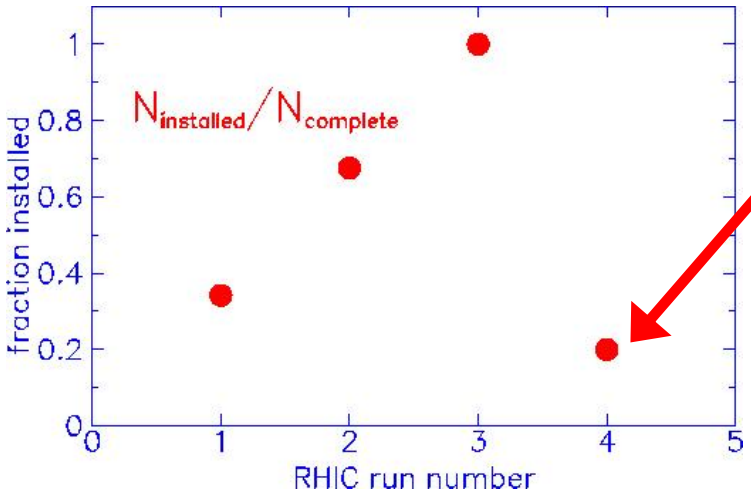
Forward / Backward Hadrons

In d+Au, yields of light hadrons at forward and backward rapidities have been measured via their decays to muons. We plan to work on the same analysis in Au+Au.

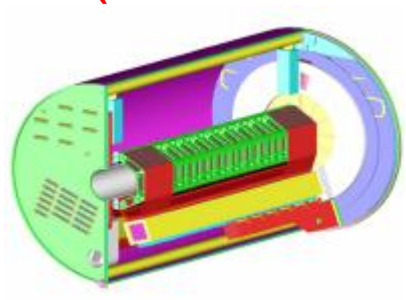


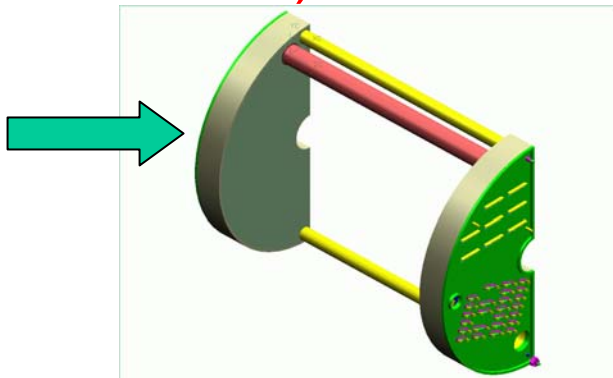
These measurements should allow us to measure high pT particle suppression at non-zero rapidity – an interesting extension of the exciting y=0 data.

MVD history in pictures



Current situation:
Only pad detectors are installed
(20% of total channels)

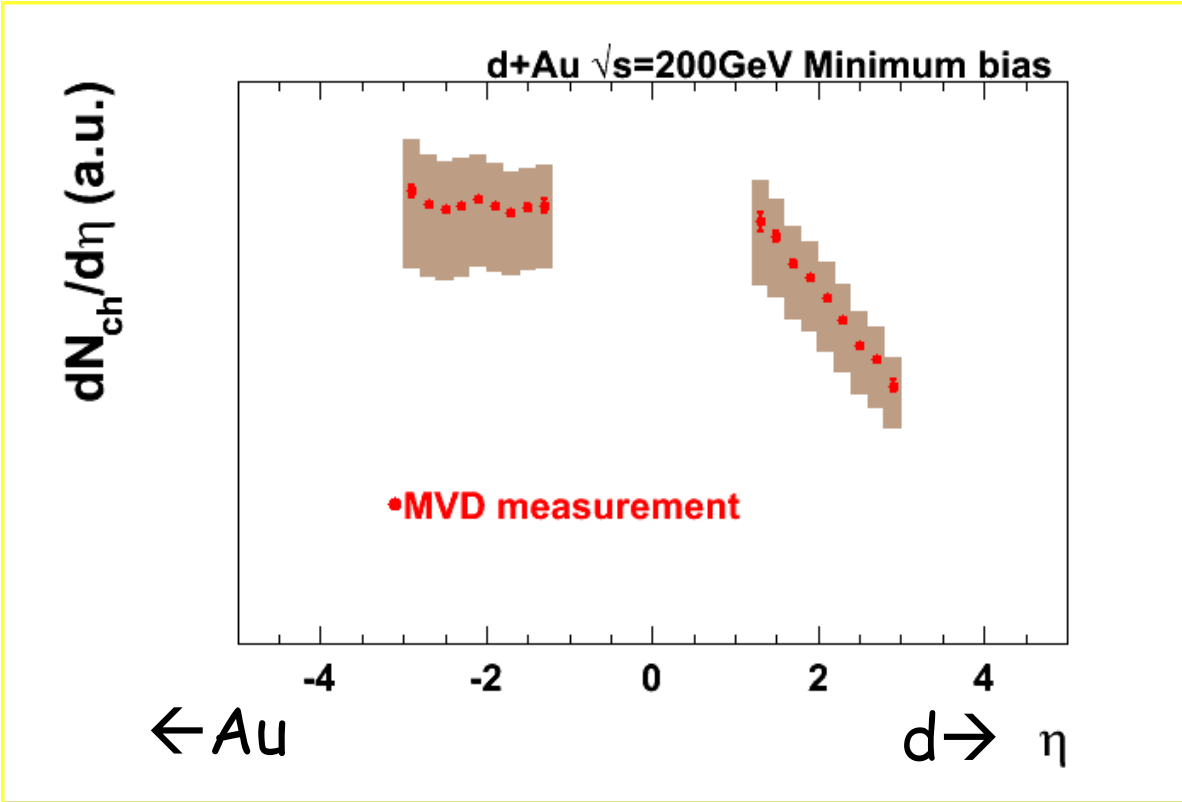




Current version (run4) of the MVD: significant contributions to multiplicity, $dN/d\eta$, centrality, and reaction plane measurements.

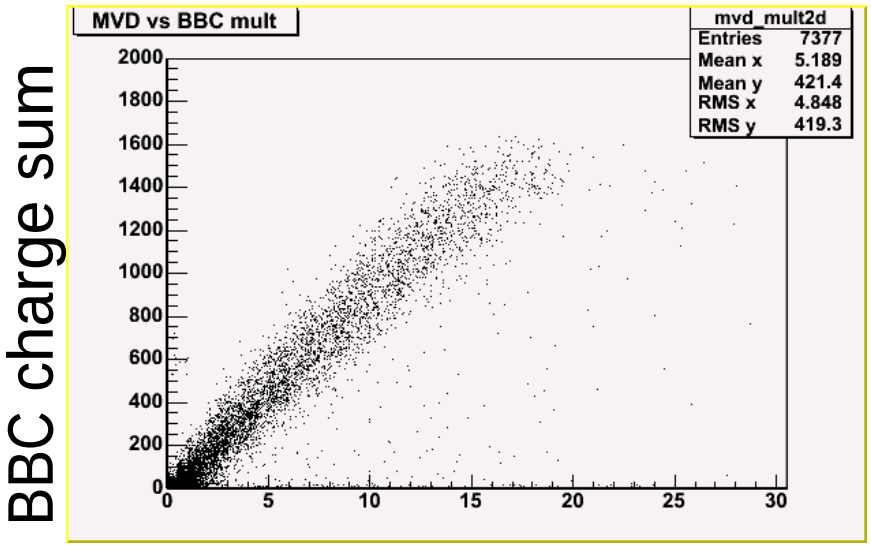
Previous versions included central silicon barrel.

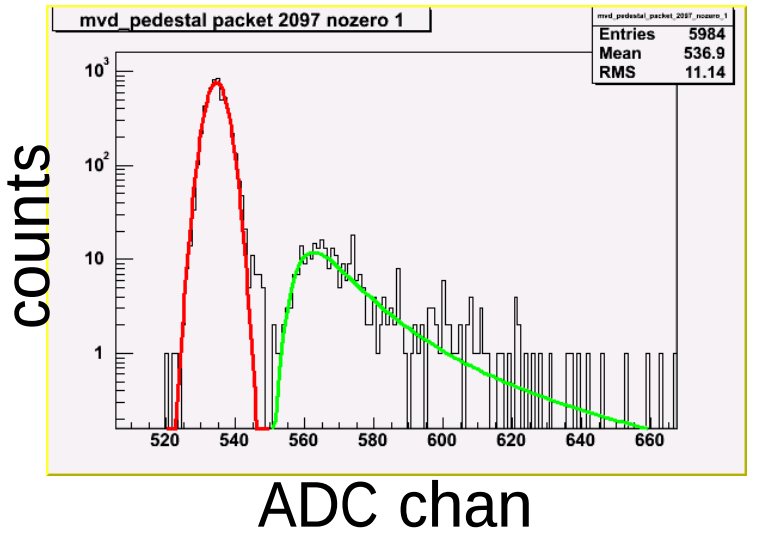
d+Au: dNch/dη for Minimum Bias events



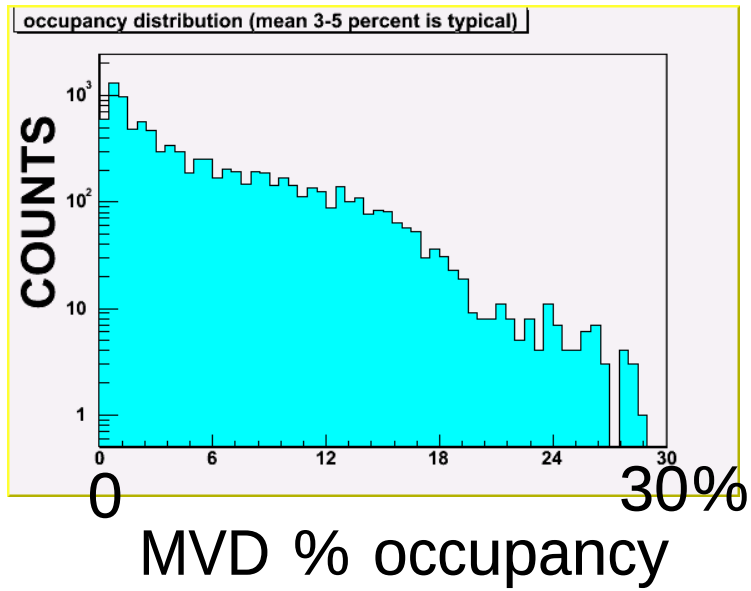
- $dN_{ch}/d\eta$ has reasonable shape
- Shaded bars represent uncertainty in the estimation of background
- Needs more background study and normalization

Run4 – MVD online monitoring plots

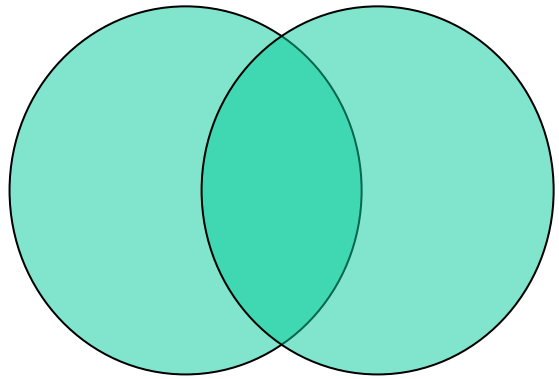




The detector is working well in run 4.



Reaction Plane Measurement



Even with only the pad detectors, the MVD should be able to make good measurements of the reaction plane in AA collisions.

Pad detectors ~25% more particles than BBC in ~47 times as many channels. (Whole MVD is x5 more particles).

MVD and BBC acceptance do not generally overlap – so these augment current BBC capabilities.

This gives another interesting way to look at jet suppression, J/Ψ suppression, open charm vs. the length of excited matter traversed.

Future analysis efforts

1) Open charm from eμ coincidences (Hiroki Sato, soon to arrive postdoc).

2) The Ψ′ is has no feed-down from higher states. The Ψ′ gives a second probe for the study of charmonium suppression.

3) Upsilon measurements. The Upsilon(1s) (b-bbar ground state) is not expected to be suppressed by color screening in a QGP. More than an order of magnitude increase in integrated Luminosity will be needed.

4) Continuum dimuon pairs (Drell-Yan) to measure sea-quark distributions.

Au-Au Summary

- J/Ψ program in Au+Au collisions underway! Will do measurements of J/Ψ yield vs. reaction plane, centrality, rapidity and transverse moemtum.
- Muon arms will also observe forward hadrons and open charm decays.
- Both muon arms are working well.
- MVD is working well in Run-4 (part is not installed, but it could have gone in with acceptable noise).